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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G02B 5/28, 27/30, G02F 1/1335	**A1**	(11) International Publication Number: **WO 98/49585** (43) International Publication Date: 5 November 1998 (05.11.98)

(54) Title: COLLIMATOR

(57) Abstract

A collimator is formed of a stack of layers (11) of different thicknesses in a way analogous to a low–pass interference filter. When illuminated by narrow–band light of a predetermined wavelength just within the pass band of the filter, the collimator preferentially transmits light incident within a predetermined angular range, usually near–normal. The collimator is especially useful with photoluminescent liquid–crystal display, having phosphor emitters (17), because the collimator layers can simply be deposited on one face of the liquid–crystal modulator (1).

COLLIMATOR

This invention relates to an improved collimator, particularly for use with a liquid-crystal display system of the type using a photoluminescent screen, such as are discussed, for instance, in WO 95/27920 (Crossland et al).

Means for producing collimated light suitable for use with liquid-crystal display cells are known. For example, IBM Technical Disclosure Bulletin (1987) discloses at page 4838 a system involving a light guide plate and a lens plate with a plurality of moulded lenslets placed in front of the plate. The moulded lenslets collimate the light passing through holes in the light guide plate. A similar arrangement is disclosed in European patent application No. 529 832 (Rockwell International). In that case, phosphors are used to provide small spots of light to be focused by a lens array.

Collimators can be desirable in liquid-crystal displays for various reasons, one being that when a diffuse light source is used the light passing through a single cell, not being collimated, will spread and cover a substantial area of the photoluminescent screen, leading to crosstalk. This will impair the resolution of the screen, and is of particular significance for LCDs using a photoluminescent screen, where in colour displays it may result in a phosphor of the wrong colour being illuminated. For the standard kinds of liquid-crystal cells increasing the collimation of the backlighting has the disadvantageous effect of reducing the angle of view of the display, though the display is brighter in the collimation direction. The light from the display thus has to be spread out again using, for instance, a diffuser plate. In photoluminescent LCDs (PLLCDs), however, the

phosphor on the front screen performs the diffusing
function to great advantage, as explained in WO
95/27920. However, prior art collimators are bulky and
require expensive manufacturing techniques to produce

5   the lens array accurately.

Anti-reflection coatings for optical components
are also known. These work on the principle that all
the light incident normal to a transparent surface of
refractive index n_1 is transmitted if the surface is

10   covered with a thin film of refractive index n_2 which
satisfies the relations:

$n_0 \times n_1 = n_2{}^2$ and $n_2 \times d = \lambda/4$

where n_0 is the refractive index of air; d is the cell
thickness; and λ is the wavelength of the light used.

15   At other angles of incidence (and at other wavelengths)
some of the light is reflected.

The anti-reflection coating only works optimally
for light at normal incidence at a specific wavelength.
However, by using a plurality of dielectric layers of

20   varying refractive index and thickness the spectral
pass band at normal incidence can be improved. The
invention is based on the recognition that thin
dielectric coatings can be put to novel use in
displays.

25   According to a first aspect of the invention there
is provided a collimator for light in a band around a
predetermined wavelength, comprising an interference
filter having a stack of dielectric layers with optical
thicknesses adapted to transmit light in the band

30   incident over a predetermined range of angles of
incidence more efficiently than light in the band
incident at other angles.

The collimator can be used in combination with a
diffuse source to provide a light input for an optical

35   modulating device, in particular an LCD. An
interference filter is particularly advantageous since

the thin film takes virtually no space and can be
incorporated as a layer on an existing component such
as a glass plate for the LCD.

5   The filter is of course suited for use with a
narrow range of wavelengths of the input light. Hence
the light source should be near-monochromatic, or
narrow-band, for best results. This would not normally
be desirable for LCDs, at least for colour displays,
but for PLLCDs it is usually the case that the input is
10   narrow-band near-visible UV light, which is ideally
suited for use with a sharp cut-off filter. The colour
output is then provided by the phosphors.

       In either the angular or wavelength domain a
general filter can be considered as one of 3 types: a
15   low-pass filter, a high-pass filter, or a bandpass
filter. When considered in the wavelength domain the
low-pass filter is also termed a short-wave pass
filter, similarly the high-pass filter is termed a
long-wave pass filter. The short-wave and long-wave
20   filters can also be referred to as edge filters, having
a single edge in their response; the position of this
edge is itself referred to as the cut-off of the
filter. For clarity the cut-off of such a filter is
generally defined as the point at which the response
25   (usually the transmission) is 50% at normal incidence.
A similar definition can be used for the cut-off of a
filter in the angular domain. Ideal transmission-
wavelength graphs for these filter types are shown in
Fig. 1.

30   Bandpass filters have two edges and therefore two
cut-offs; in the wavelength domain these are referred
to as the long-and short-wavelength cut-offs.

       It is known that the form of the response of an
interference filter, in the wavelength domain, moves to
35   shorter wavelengths as the angle of incidence
increases; this is shown diagrammatically in Figure 2.

If the performance of a filter in the wavelength
domain at normal incidence has a bandpass-type
appearance then the performance in the angular domain
at a particular wavelength can be predicted to a
greater or lesser extent using this quality. For
example, and referring to Figure 3, the performance in
the angular domain at wavelength λ_0 will be that shown
in Figure 4 (referred to as a low-pass filter) whilst
the performance at λ_1 will be that shown in Figure 5 (a
bandpass filter).

These figures are only schematic, of course,
because strictly speaking the form of the response is
not preserved exactly as the angle of incidence
increases. Figure 6 shows the actual response for a
short-wave pass edge filter prepared for use in the
invention at two angles of incidence, normal and 30°.

Nevertheless it can be seen that for wavelengths
close to the cut-off the pass characteristics are
sensitive to the angle of incidence. A wavelength of,
say, 390 nm will be largely passed at normal incidence
but nearly totally reflected at 30°.

In PLLCD applications, the required performance in
the angular domain is normally that of the low-pass
filter. In this case the required response in the
wavelength domain need not be precisely "bandpass" and
a short-wave edge filter, such as shown in Figure 4,
may well be adequate.

If near-normal light is to be passed then the cut-
off of the edge filter should be placed on the long-
wavelength side of the design wavelength (i.e. of the
peak of the spectrum of the source). For example the
cut-off for the filter of Figure 6 is at 396 nm which
is on the long-wavelength side of a design wavelength
such as 388 nm. The resulting response, in the angular
domain at 388 nm, is shown in Figure 7. This response
shows that the angular distribution of a 388 nm diffuse

source would be restricted to ±25° or so upon passing
through the filter.

A tighter distribution would be achieved by
placing the cut-off closer to the design wavelength,
and clearly a trade-off takes place: increasing the
cut-off wavelength maximises the transmission of light,
but the light will have a wider angular divergence. On
the other hand if the cut-off wavelength is lowered, so
that the wavelength of the monochromatic light lies
near or even on the steep edge at the limit of the pass
band of the graph of transmission coefficient against
wavelength, then improved collimation results at the
cost of lower brightness.

For practical filters such as are shown in Fig. 6
the steep edge terminates at the top in a smaller or
larger peak or "first maximum" whose size depends on
the quality of the filter. This peak is useful for
defining the wavelength of the source in relation to
the filter characteristics. In general the
predetermined wavelength should be close to the cutoff,
on its short wavelength side, to allow sufficient
throughput of light. The layers could be adapted to
ensure that the transmission at the predetermined
wavelength is at least 80 or 90% of the transmission at
the first maximum. As an alternative criterion, if the
light source has a finite bandwidth Δ (as in practice
it will) then the cutoff of the filter should be
designed to ensure that substantially all (at least
90%) of the light output is passed (not reflected) by
the filter.

In a variant embodiment, if only off-normal light
should be transmitted, a high-pass filter can be used,
with the source wavelength (i.e. the predetermined
wavelength) lying on the short-wavelength side of the
cut-off.

The substrate is preferably a flat plate and the

-6-

collimator is used in combination with an optical
device which makes use of the collimated light output.

The efficiency of a simple stack can be quite low,
for example an ideal low-pass angular filter with the
5   cut-off at 30°, would have an efficiency of 50% when
used with a Lambertian source. In order to improve the
efficiency or overall throughput a means of
regenerating the rejected light is provided; this is
possible because light that is not passed by the filter
10   is not absorbed but, in the case where the filter is
being used in transmission, reflected. The rejected or
reflected light is then re-presented to the filter by a
suitable means, exemplified by a highly reflecting but
diffusing mirror (see Figure 8).

15   Since there are many parameters that can be varied
to adjust the transmission spectrum the easiest
procedure to design a collimator according to the
invention is to use a computer program which can
calculate the transmission coefficient as a function of
20   wavelength and angle for a plurality of layers of given
dielectric constants. Such a computer program is not
difficult to write.

The two dielectric materials are preferably chosen
to have refractive indices, at the predetermined
25   wavelength, as widely spaced as possible. For example,
tantalum pentoxide (Ta_2O_5) and silicon dioxide (SiO_2)
may be chosen, which have refractive indices of about
2.3 and 1.47 respectively at a wavelength of 388 nm.
Titanium dioxide (TiO_2) would be an alternative (if
30   somewhat lossy) higher-refractive-index material, and
magnesium difluoride an alternative lower refractive
index material.

Once the materials are selected their thicknesses
must be chosen. A suitable program can then be used to
35   evaluate the performance of the resulting filter. Good
results have been obtained by selecting the high

-7-

refractive index layers to have identical thicknesses
of a quarter of the predetermined wavelength, for
instance.

5   Terminology such as $(HL)^n$ will be used in which H
refers to a layer of high-index material and L refers
to a layer of low-index material. The thickness of
each layer is considered to be one quarter wavelength
in the appropriate medium. A regular stack can be
created by repeating the layers within the brackets 'n'
10   times; hence a $(HL)^{10}$ design will have 20 layers, 10 of
each material. Furthermore, arbitrary designs can be
described with this terminology, such as $(HL)^3(2H)(LH)^3$
for example. See James D Rancourt, 'Optical Thin Films
- Users' Handbook' for further explanation and
15   examples.

           The preferred embodiment of a short-wave-pass
filter such as can be used to restrict the angular
distribution of light as described above is designed by
designing an $(HL)^n$ filter positioned correctly in the
20   wavelength domain and then using an optimisation
algorithm, e.g. as provided in TFCalc, to improve the
performance against appropriate optimisation targets.
This process is shown in Figure 9 and Figure 10. If
the pass band in the wavelength domain has been
25   positioned correctly by the above process then the
required performance in the angular domain will be
achieved. Figure 9 shows the un-optimised edge filter
constructed from a $(HL)^{13}$ stack, whilst Figure 10 shows
the edge filter after optimisation.

30   The collimator according to the invention has the
apparent disadvantage that it is only suitable for
light in a wavelength band around the predetermined
wavelength. However, for applications using
substantially monochromatic light this is not a
35   disadvantage and the greater simplicity, ease of
manufacture and reduced thickness of the collimator

-8-

according to the invention as compared to multiple lens. arrays is highly advantageous. The collimator is therefore preferably used in combination with a source of matched substantially monochromatic light.

Preferably, the layers are inorganic layers, which can be deposited using known techniques. Preferably, no more than two different dielectric materials are used provided alternately on the substrate surface. In order to achieve sufficient angular discrimination, it is generally necessary to provide at least three pairs of dielectric layers. In some current embodiments, around twenty-five pairs are used, which provide good angular discrimination without creating excessive manufacturing difficulties.

For PLLCDs the predetermined wavelength is preferably about 388 nm, but 365 nm (a common wavelength for mercury discharge lamps) can also be used. The dielectrics should have refractive indices as widely separated as possible. A predetermined wavelength of 405 nm is possible in alternative embodiments. It is also conceivable to select the wavelength for a given stack, rather than to adapt the stack for a given wavelength. However, since most light sources emit at a fixed wavelength it is generally easier to adjust the thicknesses of the layers.

The invention can be used to collimate light for a liquid-crystal display, or at least to improve the collimation of light in such a display. Such a liquid-crystal display can include a liquid-crystal cell for modulating monochromatic light sandwiched between a front and a rear transparent substrate, in which a stack of layers with different dielectric constants is provided on the rear transparent substrate adapted to transmit light in a predetermined narrow-wavelength band incident substantially normally to the substrate

and to reflect such light incident at other angles, e.g. above about 25°.

Preferably, the liquid-crystal display is a photoluminescent liquid-crystal display (PL-LCD) in which a photoluminescent layer is provided at the front transparent substrate. The liquid-crystal display may be of the type having two polarisers sandwiching the liquid-crystal cell, one provided on the outside of each of the transparent substrates. The polarisers could be either linear or circular, and for some types of liquid- crystal cell one of each is used. The stack is preferably placed on (i.e. on the light-source side of) the first polariser.

Preferably, the liquid-crystal display further comprises a light source arranged behind the rear transparent substrate to produce the narrow-band input radiation.

Most of the light emitted by the light source is not transmitted by the plurality of layers and is specularly reflected from them. Therefore, in order not to waste this reflected light, a diffuse reflector is preferably provided behind the light source, as mentioned above. Some of the light reflected by the diffuse reflector will be within the desired angular pass band and will be transmitted by the plurality of layers; the rest of the light will be reflected once again back to the diffuse reflector for further reflection back towards the LCD.

In edge-lit embodiments, the light source may be provided at the side of the transparent substrate and a scattering surface provided on the opposite side of the transparent substrate to the stack of layers.

For a better understanding of the invention a specific embodiment will now be described, purely by way of example, with reference to the accompanying figures, in which:

Fig. 1 shows schematic transmission coefficients of ideal edge and band-pass filters,

Fig. 2 shows the shifted response of a band-pass filter with a varying angle of incidence,

Fig. 3 shows an ideal band-pass filter in the wavelength domain,

Fig. 4 shows the incidence angle dependence of the filter shown in Fig. 3 at a wavelength λ_0,

Fig. 5 shows the incidence angle dependence of the filter shown in Fig. 3 at a wavelength λ_1,

Fig. 6 shows an actual filter response at two angles of incidence 0° and 30°, for light of wavelength 388 nm,

Fig. 7 shows the incidence angle dependence of the filter of Fig. 6,

Fig. 8 shows a schematic arrangement according to the invention,

Fig. 9 shows the transmission of an unoptimised edge filter constructed from a $(HL)^{13}$ stack,

Fig. 10 shows the edge filter after optimisation,

Fig. 11 shows a schematic of a liquid-crystal display device according to the invention, and

Fig. 12 shows an alternative backlight arrangement.

In Fig. 11, a liquid crystal layer 1 is shown contained between a front transparent substrate 3 and a rear transparent substrate 5. Two polarisers 7, 9 are provided between the liquid crystal cell and the transparent substrates. Electrodes are provided on the transparent substrates 3, 5 to control the liquid crystal cell 1. In this embodiment, the transparent substrates 3, 5 are made of glass. A dielectric stack 11 is provided on the rear face of the rear transparent substrate 5. A diffuse reflector 15 is provided behind the rear of the display, and a light source 13 is provided between the diffuse reflector 15 and the

dielectric stack 11. The light source can be, for
instance, a set of phosphor-coated mercury vapour
discharge tubes, emitting UV light at about 365 or
388 nm. RGB Phosphors 17 are provided on the front
5   transparent substrate 3 to provide the visible image
when struck by UV light passed by the liquid crystal.

The dielectric stack 11 comprises a stack of pairs
of dielectrics. The chosen dielectrics in many
embodiments are Ta_2O_5 and SiO_2 whose refractive indices
10   are n = 2.3 and n = 1.47 respectively at a wavelength λ
of 388 nm. In a first embodiment the thickness of the
layers with the lower dielectric constant is given by
$\lambda/4$, here 97 nm, and the layers with the higher
dielectric constant have a thickness of $\lambda/2.955$, here
15   131 nm (or 91 and 124 nm respectively for light at
365 nm). In a more sophisticated embodiment the
thickness of each layer is chosen independently, and
twenty-five pairs of layers make up the dielectric
stack 11, i.e. fifty layers are provided, twenty-five
20   each of Ta_2O_5 and SiO_2 in an alternating arrangement.
The thicknesses are as given in the table at the end of
the description. In an alternative embodiment pairs of
layers of titanium dioxide and magnesium difluoride are
used.

25   Fig. 6 shows the transmission coefficient T of the
dielectric stack used in the embodiment of Figure 11 as
a function of wavelength. As can be seen, maximum
reflection of the dielectric stack occurs for
wavelengths between 400 nm and 480 nm and maximum
30   transmission occurs below about 385 nm. A suitable
light source is a low-pressure mercury discharge lamp
with a phosphor which emits light around a wavelength
of 365 nm in a wavelength band of width approximately
20 nm; more recently phosphors emitting at around
35   388 nm have been used, with an advantageously narrow
FWHM bandwidth of 13-14 nm - see for instance

-12-

L Ozawa and HN Hersch, Journal of the Electrochemical
Society, Vol 122 No 9, p. 1222 (1975).

The transmission coefficient of the stack as a
function of incident angle at 388 nm is shown in
Fig. 7. As can be seen, transmission for light 20°
away from normal is much less than for normally
incident light, and very little light incident at 30°
from the normal is transmitted. Whether such
collimation is sufficient depends on the pixel size and
exact structure of the display, and on the opto-
electronic properties of the liquid crystal. In any
event, the collimation is an improvement. Such
collimation is particularly important for colour PL-LCD
displays in which it is important that light hits the
phosphor having the correct colour, and not a
neighbouring phosphor, which generally has a different
colour.

In use, the light source 13 emits light (shown in
Fig. 11 using arrows). The source is shown
schematically as a point but in practice would be one
or more tubes. Part of the light is emitted in the
correct direction, is normally incident on the
dielectric stack and passes through it. The remainder
of the light is reflected back to the diffuse reflector
15. This reflector returns the light to the dielectric
stack at various angles; once again some will pass
through the dielectric stack and most will be
reflected, repeating the process.

The dielectric stack transmits only a small
proportion of the incident light. Therefore, it is
very important that the diffuse reflector has a good
reflectivity in order to avoid wasting too much of the
emitted light.

The light incident upon the dielectric stack at a
substantially normal angle of incidence is transmitted
through to the liquid crystal cell 1. The liquid

crystal 1, in conjunction with the polarisers 3, 5, modulates the light. The phosphors 17 of the photoluminescent screen emit visible light to form the image where they are excited by light transmitted
5   through the polarisers 3, 5 and the liquid crystal cell. In the region where no light is transmitted through the polarisers 3, 5 and cell 1, the phosphors 17 remain dark.

The dielectric stack in this embodiment has
10   another advantage when combined with a liquid crystal display using phosphors and ultraviolet light (i.e. light of a wavelength less than about 400 nm): it filters out the visible lines of a mercury lamp, at least for normal incidence, at wavelengths between 400
15   and 480 nm, as can be seen from Figure 6. The peaks of transmission above 480 nm belong to the 30° curve.

The collimator of the present invention can be combined with other collimating components if desired. Furthermore, it is possible to mount the dielectric
20   stack on other components of a liquid-crystal display system and not directly onto the transparent substrate surrounding the liquid-crystal cell. Indeed, the collimator is useful wherever rough collimation of highly monochromatic light is required and not
25   necessarily only for displays.

Fig. 12 shows an alternative backlight arrangement. Light sources 13, e.g. phosphor-coated low pressure mercury discharge tubes with suitable reflectors as shown, are provided around the edges of a
30   flat transparent substrate 19; a diffuse reflector 15 is provided on the rear of the transparent substrate and the dielectric stack 11 on the front surface. The arrangement operates in the same way as the arrangement of Fig. 11, except that the light source is no longer
35   between the diffuse reflector and the stack.

-14-

TABLE

			/nm		/nm
	1st pair	Ta_2O_5	64.55	SiO_2	85.06
5	2nd pair	Ta_2O_5	53.18	SiO_2	78.83
	3rd pair	Ta_2O_5	50.06	SiO_2	79.53
	4th pair	Ta_2O_5	52.17	SiO_2	76.02
	5th pair	Ta_2O_5	50.66	SiO_2	76.08
	6th pair	Ta_2O_5	49.86	SiO_2	78.21
10	7th pair	Ta_2O_5	51.33	SiO_2	74.10
	8th pair	Ta_2O_5	49.98	SiO_2	75.34
	9th pair	Ta_2O_5	51.15	SiO_2	77.02
	10th pair	Ta_2O_5	50.03	SiO_2	77.47
	11th pair	Ta_2O_5	49.16	SiO_2	76.33
15	12th pair	Ta_2O_5	48.56	SiO_2	77.33
	13th pair	Ta_2O_5	50.66	SiO_2	77.64
	14th pair	Ta_2O_5	48.62	SiO_2	76.33
	15th pair	Ta_2O_5	50.08	SiO_2	78.62
	16th pair	Ta_2O_5	49.88	SiO_2	76.80
20	17th pair	Ta_2O_5	49.70	SiO_2	75.73
	18th pair	Ta_2O_5	51.11	SiO_2	76.91
	19th pair	Ta_2O_5	51.40	SiO_2	78.40
	20th pair	Ta_2O_5	47.41	SiO_2	81.94
	21th pair	Ta_2O_5	54.55	SiO_2	77.57
25	22th pair	Ta_2O_5	56.02	SiO_2	91.77
	23th pair	Ta_2O_5	60.17	SiO_2	95.25
	24th pair	Ta_2O_5	59.75	SiO_2	82.80
	25th pair	Ta_2O_5	58.70	SiO_2	38.31

CLAIMS

1.   A collimator for light in a narrow band
around a predetermined wavelength, comprising an
interference filter (11) having a stack of dielectric
5   layers with optical thicknesses adapted to transmit
light in the band incident at a predetermined range of
angles of incidence more efficiently than light in the
band incident at other angles.

10   2.   A collimator according to claim 1 in which
the predetermined range of angles of incidence is
centred at normal incidence.

3.   A collimator according to claims 1 or 2,
15   in which the interference filter includes a low-pass
region with a cut-off wavelength longer than the
predetermined wavelength.

4.   A collimator according to claim 3, in
20   which the response of the filter has a first peak of
transmission at the short wavelength side of the cut-
off at a wavelength which is less than or equal to the
predetermined wavelength.

25   5.   A collimator according to claim 4, in
which the first-peak wavelength approximately equals or
is slightly shorter than the predetermined wavelength.

6.   A collimator according to claim 1 or 2, in
30   which the interference filter includes a high-pass
region with a cut-off wavelength longer than the
predetermined wavelength.

7.   A collimator according to any preceding
35   claim, wherein the predetermined wavelength falls in
the visible region.

-16-

8.   A collimator according to any of claims 1
to 6, wherein the predetermined wavelength falls in the
ultra-violet.

5   9.   A directional light source including a
collimator according to any preceding claim and a
diffuse lighting arrangement adapted to produce light
in a narrow band around the predetermined wavelength.

10   10.   A light source according to claim 9,
further having a means to return light rejected by the
collimator to the collimator to improve the light
throughput.

15   11.   A liquid-crystal display, including
a collimator (11) according to any of claims 1 to
8, or a light source according to claim 9 or 10, and
a liquid-crystal modulator (1) for modulating
light.
20

12.   A liquid-crystal display according to
claim 11, further including a photoluminescent layer
(17) for receiving the modulated light and producing a
display.

25

13.   A liquid-crystal display according to
claim 12, wherein the interference filter is formed
directly on one face of the liquid-crystal modulator
and the photoluminescent layer is formed on the
30   opposite face.

Cut-off

Low Pass

High Pass

Band Pass

Figure 1

transmission

Non-normal

Normal incidence

wavelength
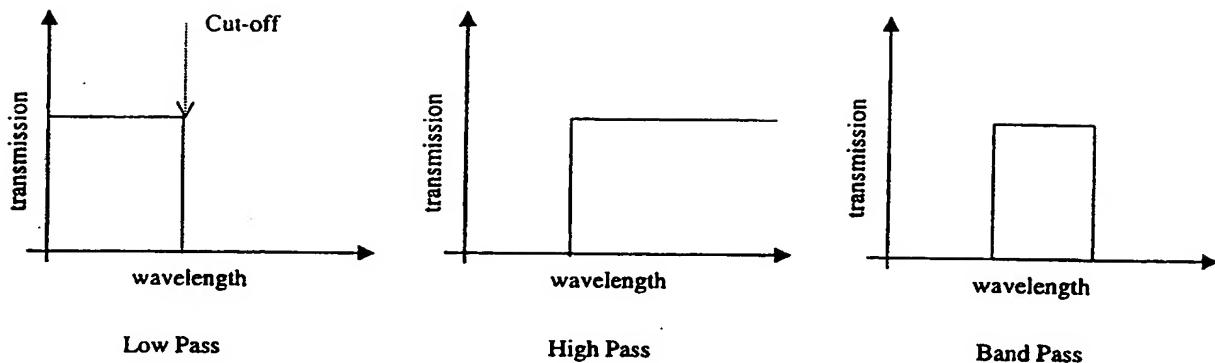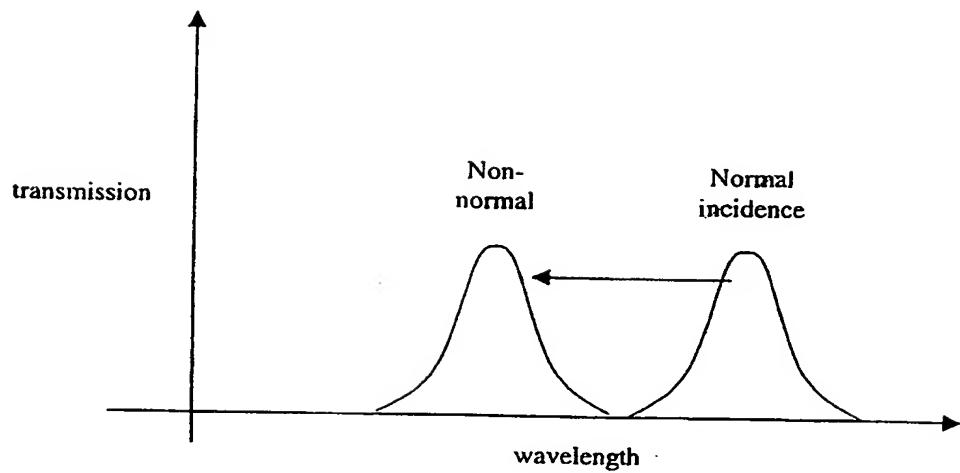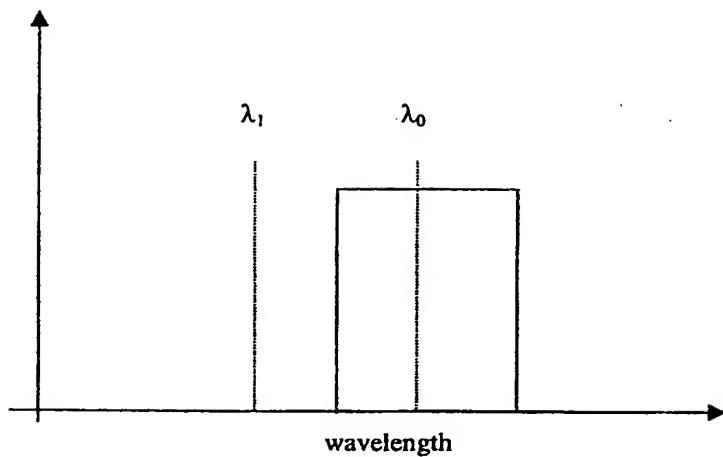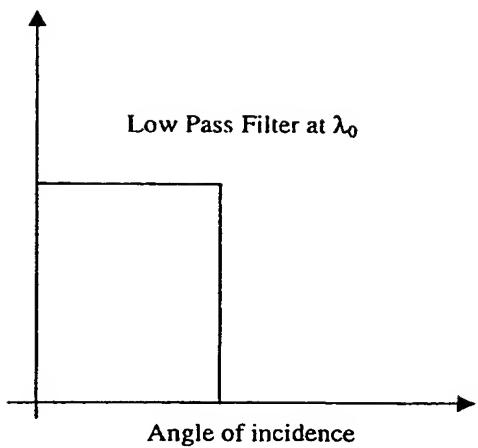
Figure 2
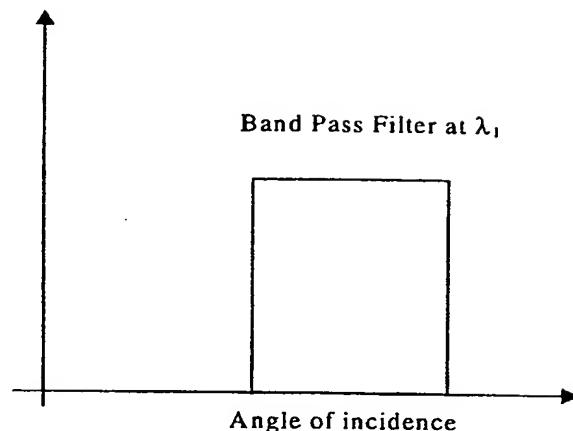
Figure 3

Figure 4



Figure 5
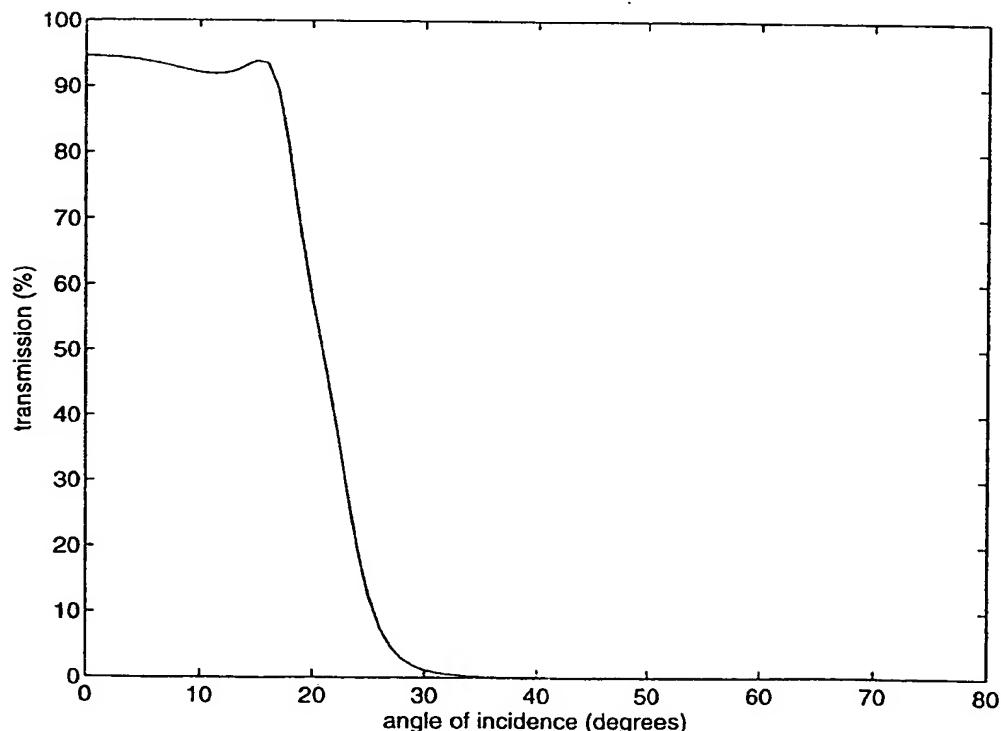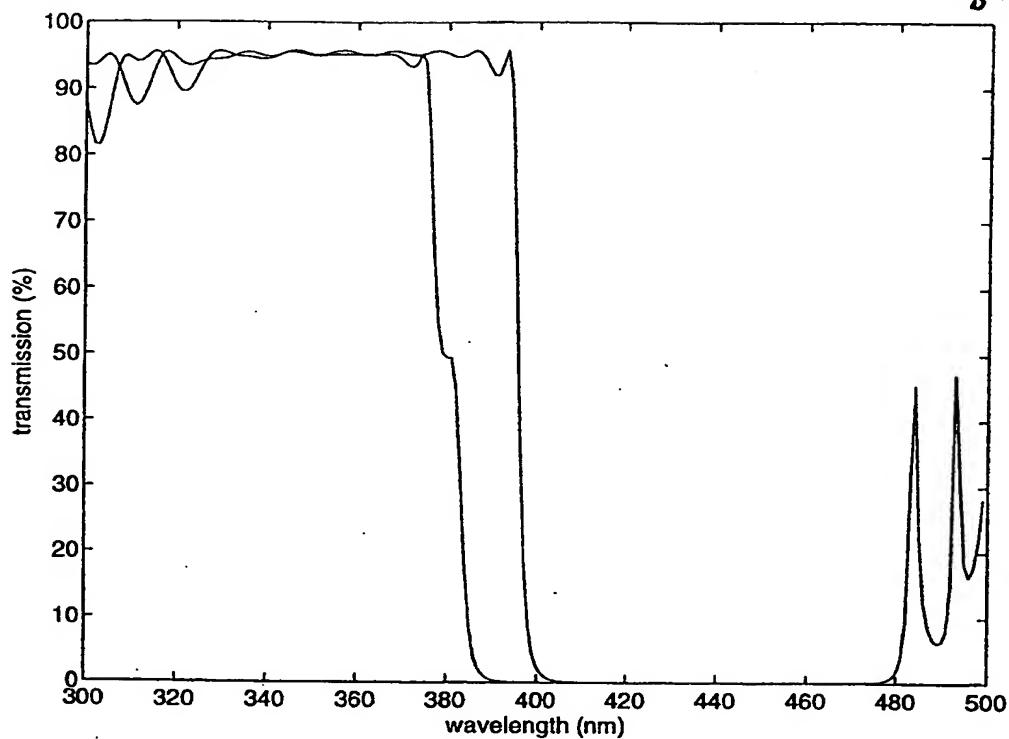
Figure 6

Figure 7

SUBSTITUTE SHEET (RULE 26)

Lambertian source
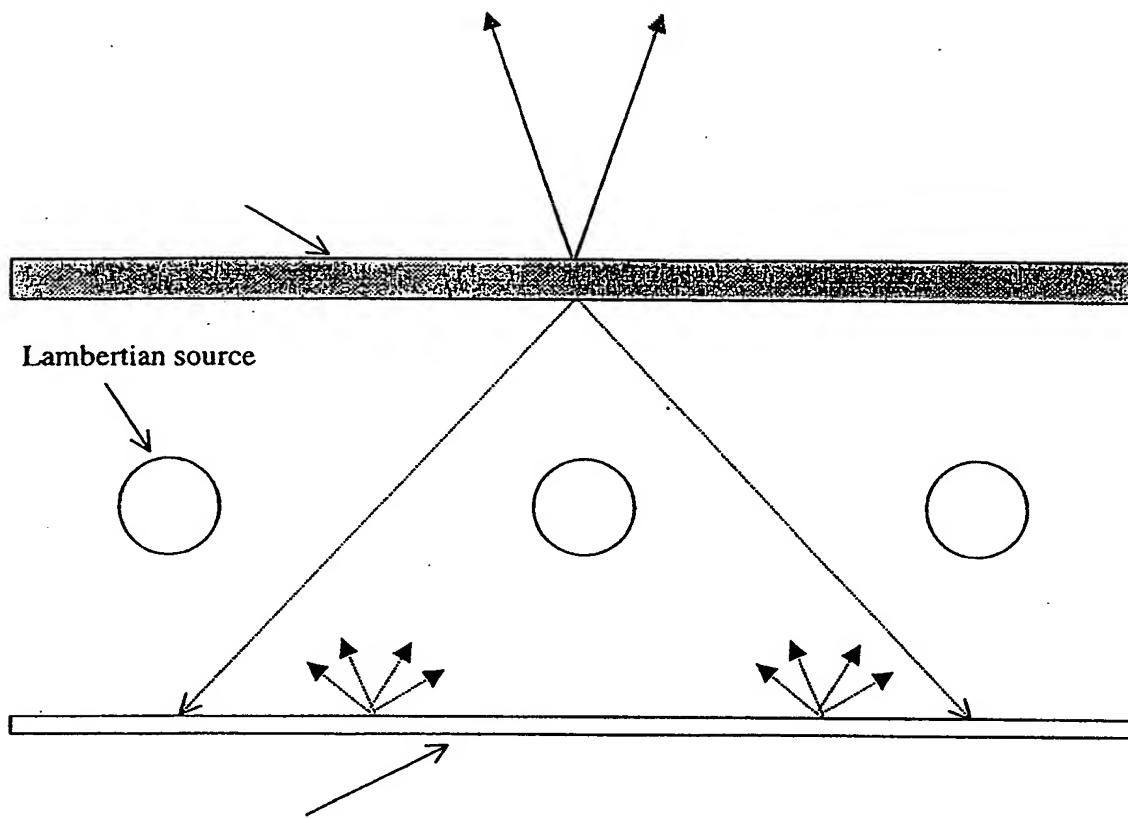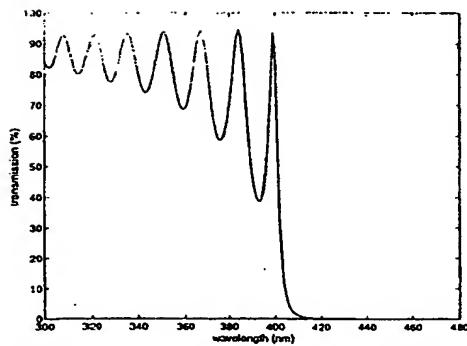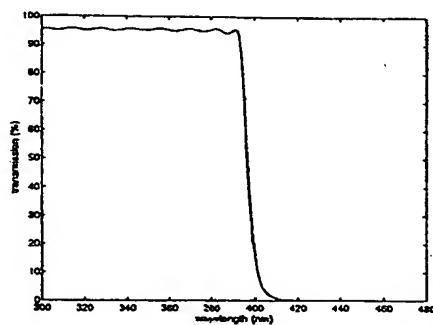
Figure 8

Figure 9

Figure 10

5/5
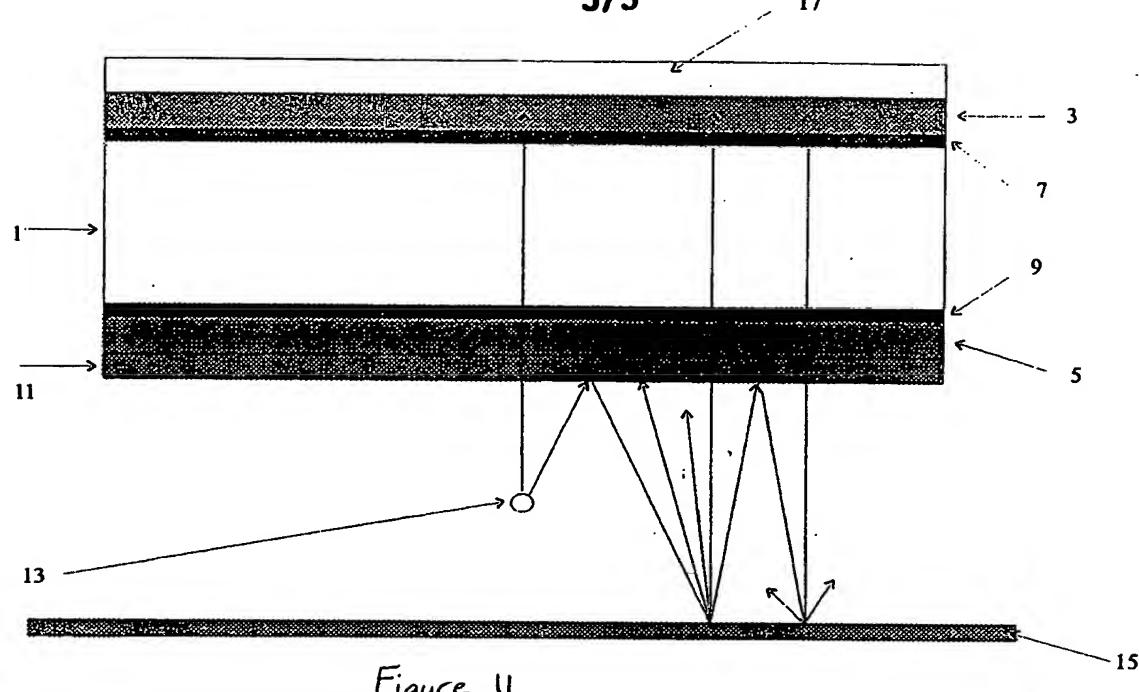
Figure 11
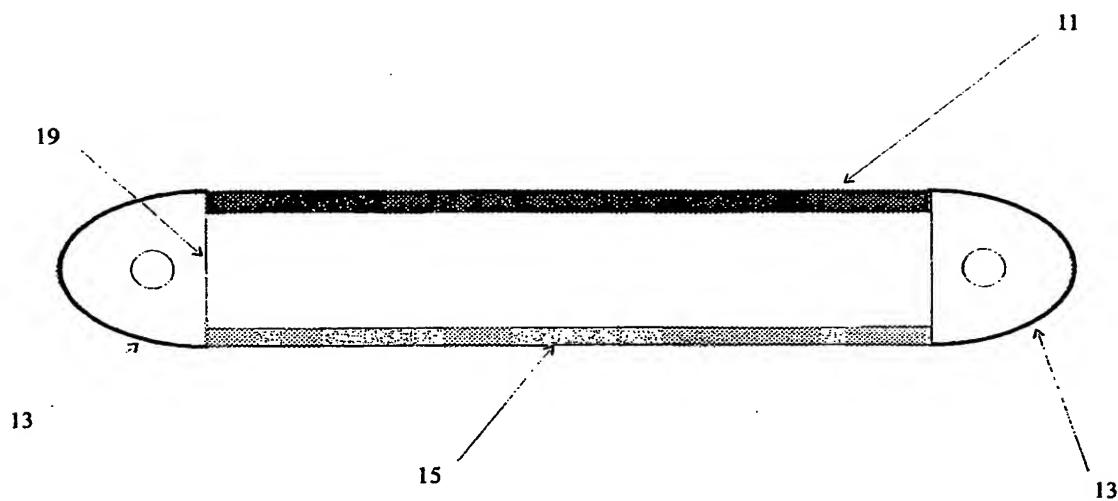
Figure 12

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6   G02B5/28   G02B27/30   G02F1/1335

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6   G02B   G02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category°	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 095, no. 005, 30 June 1995 -& JP 07 043528 A (FUJI PHOTO FILM CO LTD), 14 February 1995	1,2,7
A	see abstract; figures	9,11
X	PATENT ABSTRACTS OF JAPAN vol. 008, no. 171 (P-293), 8 August 1984 -& JP 59 067503 A (MATSUSHITA DENKI SANGYO KK), 17 April 1984	1,2,7,9
A	see abstract; figures	11
X	US 5 572 500 A (IKEYA TOMOYOSHI ET AL) 5 November 1996	1,2
A	see the whole document	9,11

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[X] Further documents are listed in the continuation of box C.   [X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 August 1998	21/08/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ward, S

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4

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category°	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 017, no. 669 (P-1657), 9 December 1993 -& JP 05 224002 A (FUJI PHOTO OPTICAL CO LTD), 3 September 1993 see abstract; figures ---	1,2,7,9, 11
A	CHEREPANOVA M N ET AL: "Optical Properties of Narrow-Band Interference Filters as Function of Incidence Angle and Polarization of the Incident Light" SOVIET JOURNAL OF OPTICAL TECHNOLOGY, vol. 46, no. 1, January 1979, pages 57-58, XP002073633 see the whole document ---	1
A	WO 95 27920 A (CROSSLAND WILLAM ALDEN ;DIXON ALAN COLIN (GB); THOMAS JOHN (GB)) 19 October 1995 cited in the application see the whole document ---	1,9,11
A	EP 0 529 832 A (ROCKWELL INTERNATIONAL CORP) 3 March 1993 cited in the application see the whole document ---	1,9,11
A	"BACKLIGHTING FOR LIQUID CRYSTAL DISPLAY" IBM TECHNICAL DISCLOSURE BULLETIN, vol. 29, no. 11, 1 April 1987, pages 4838-4839, XP002001571 cited in the application see the whole document -----	1,9,11

4

INTERNATIONAL SEARCH REPORT

information on patent family members

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
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WO 9527920	A	19-10-1995	AU	2112195 A	30-10-1995
			BR	9507295 A	30-09-1997
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